Gamma Ray Energy Tracking Array

Detecting Nuclear Materials by Measuring the Energy and Direction of Gamma Rays

A Gamma Ray Energy Tracking Array (GRETA) uses highly segmented Ge detectors, and digital pulse-shape analysis of signals from each segment to obtain the energy and three-dimensional positions of all γ-ray interactions. This allows the scattering sequence of a γ ray to be tracked and reconstructed. Compared with current generation γ ray detectors, GRETA will have higher efficiency (especially for high energy γ rays), higher peak-to-total ratio, the ability to handle higher counting rates, and most importantly, provide directional information of the γ ray. The directional information will enable the localization and imaging of radioactive sources, and improved sensitivity for detecting remote sources.

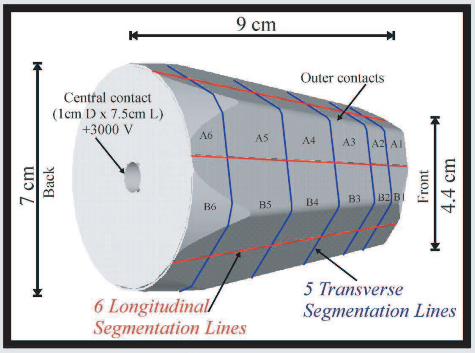

Figure 1

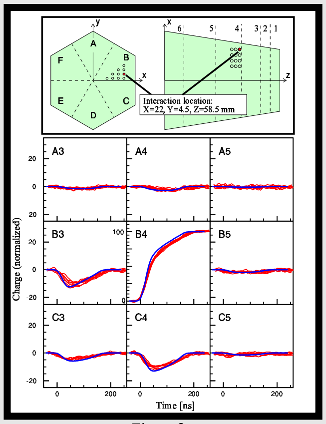

Figure 2

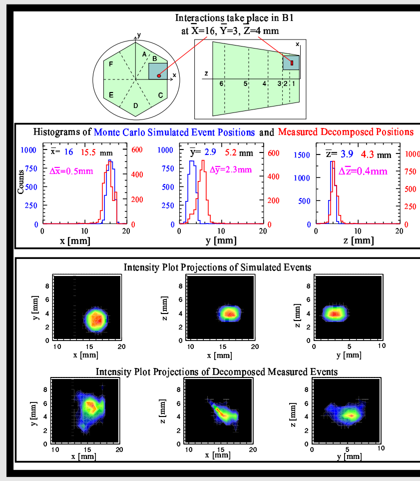

Figure 3

The crystal of the GRETA prototype is shown in **Figure 1**. The outer electrode is segmented into 36 segments. The current prototype detector provides excellent energy resolution ~1.2 keV @60 keV and ~2 keV @ 1.3 MeV. **Figure 2** shows a set of 10 measured (red) signals and the calculated (blue) signal for a single γ-ray interaction at the location shown in the top of the figure. Excellent agreement is seen between the measured signals and the theoretical signal calculated. Most significantly, the induced signals are fully understood. The three-dimensional position and energy of each γ-ray interaction will be determined by using pulse-shape analysis of the signals from the detector. **Figure 3** shows a comparison of reconstructed experimental interaction points with that of the simulation. The top of **Figure 3** shows where the interactions take place in the detector. The middle and bottom of the figure show the 1D and 2D distributions of the measured and simulated interaction positions. Tracking algorithms, for both Compton and pair-production events, have been developed to identify interactions belonging to a single γ-ray.

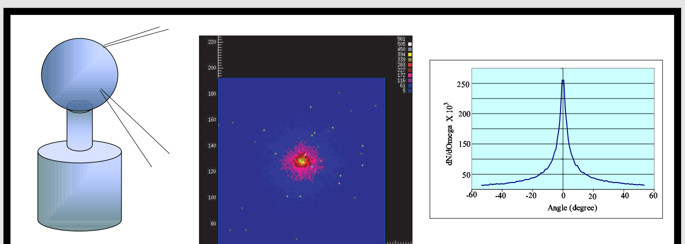

Figure 4

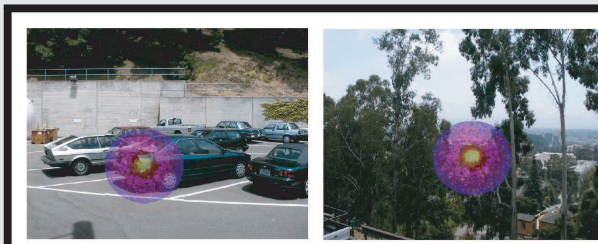
Figure 5

GRETA will provide a number of new and improved capabilities in detecting, locating and characterizing radioactive material. At distances comparable to the size of the radioactive material, images of the material can be obtained. This will provide the size, shape and spatial distribution of the material. As shown in **Figure 4,** an angular resolution of ± 3 degrees is obtained in a simulation of 1.2 MeV γ-rays using a shell of segmented Ge detectors with a position resolution of 2 mm. At large diameters, the direction of the γ-rays can be determined. Using two measurements or two detectors with adequate separation, the location of the material can be determined. **Figure 5** indicates the capability of GRETA in locating radioactivity in vehicles and buildings. The high efficiency of the array combined with the reduced background due to directional discrimination, will provide higher sensitivity in detecting smaller amounts of material at larger distances in shorter times. Such detectors can be installed at ports of entry such as airports, seaports and broader crossings, to detect and characterize radioactive material brought in by terrorists.

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